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	Title	Pub. Date	Int. Class	App. Num	Applican
1.	(WO 2002/056519) OCDMA NETWORK ARCHITECTURES, OPTICAL CODERS AND METHODS FOR OPTICAL CODING	18.07.2002	H04J 14/00	PCT/EP2001/000374	NOKIA CORPOF

The invention relates to a OCDMA network architectures. In order to achieve a less expensive frequency-hopping coding f number of users, the network comprises: a plurality of means (81) for passband filtering and multiplexing broadband signa said means (81) being assigned to a group of users (80) and filtering a broadband signal provided by a user (80) of the res group with a different frequency passband and multiplexing the filtered signals of the users (80) of one group; a periodic op (82) assigned to each group of users (80) for encoding the signals multiplexed by the means (81) for filtering and multiplex coder (82) using a different code for encoding the signals originating from the differ...

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	Title	Pub. Date	Int. Class	App. Num	Applicant
1.	(WO 2004/030254) ENHANCED OPTICAL FAST FREQUENCY HOPPING-CDMA BY MEANS OF OVER SPREADING AND INTERLEAVING	08.04.2004	H04J 14/00	PCT/CA2003/001460	ACCESSPHOT NETWORKS IN

A method and an optical communication system for a practical implementation of fast frequency hopping-code division mu in optical networks allowing higher transmission bandwidth is provided. The method comprises the step a) of providing a fa hopping CDMA coded optical signal comprising a plurality of user's bits of a plurality of users. The method also comprises over spreading in a time axis each of the user's bits of the fast frequency hopping CDMA coded optical signal. The method comprises the step c) of interleaving each of the user's bits of a given user with a successive user's bit of the given user. A b) and c), the method comprises the step d) of transmitting the fast frequen...

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(WO/2004/030254) ENHANCED OPTICAL FAST FREQUENCY HOPPING-CDMA BY MEANS OF OVER SPREADING AND INTERLEAVING

Latest bibliographic data on file with the International Bureau

Pub. No.: WO/2004/030254 International Application No.: PCT/CA2003/001460
Publication Date: 08.04.2004 International Filing Date: 24.09.2003

IPC: *H04J 14/00* (2006.01)

Applicants: ACCESSPHOTONIC NETWORKS INC. [CA/CA]; 2740 rue Einstein, Suite 723, Sainte-Foy, Québec G1P 4S4 (CA) *(All Except US).*
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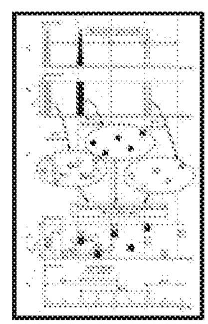
Inventors: FATHALLAH, Habib; 800 de Villiers, Apt. 113, Sainte-Foy, Québec G1V 4T8 (CA).
FOULI, Kerim; 870, rue St-Jean Bosco, Appt. 1, Sainte-Foy, Québec G1V 2W7 (CA).

Agent: ROBIC; Leger Robic Richard, CDP Capital Center, 1001, Victoria Square, Bloc E - 8th Floor, Montreal, Quebec H2Z 2B7 (CA).

Priority Data: 60/413,134 25.09.2002 US

Title: ENHANCED OPTICAL FAST FREQUENCY HOPPING-CDMA BY MEANS OF OVER SPREADING AND INTERLEAVING

Abstract: A method and an optical communication system for a practical implementation of fast frequency hopping-code division multiple access in optical networks allowing higher transmission bandwidth is provided. The method comprises the step a) of providing a fast frequency hopping CDMA coded optical signal comprising a plurality of user's bits of a plurality of users. The method also comprises the step b) of over spreading in a time axis each of the user's bits of the fast frequency hopping CDMA coded optical signal. The method also comprises the step c) of interleaving each of the user's bits of a given user with a successive user's bit of the given user. After steps a), b) and c), the method comprises the step d) of transmitting the fast frequency hopping CDMA coded optical signal over the optical network. The method also comprises, after step d), the step e) of over de-spreading in the time axis each of the user's bits of the fast frequency hopping CDMA coded optical signal. The method also comprises the step f) of deinterleaving each of the user's bits of the fast frequency hopping CDMA coded optical signal from the successive user's bit.



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Publication Language: English (EN)

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groups, and assigned the codes, which interleaved to each other. to the different groups. ... first FFH-CDMA in optical domain is proposed by using an ...
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Spread-spectrum, frequency-hopping radio telephone system with voice activation

5619493 Spread-spectrum, frequency-hopping radio telephone system with voice activati

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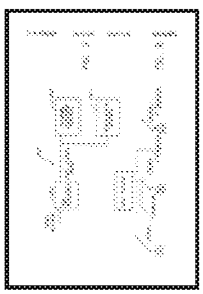
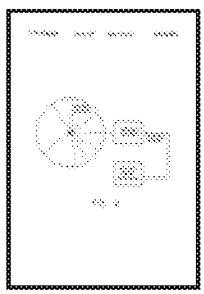
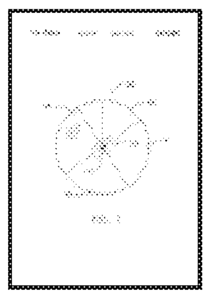
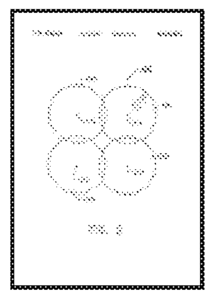
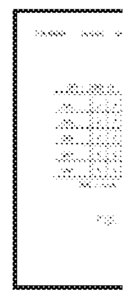

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(10 images)

Inventor:	Ritz, et al.
Date Issued:	April 8, 1997
Application:	08/606,587
Filed:	February 26, 1996
Inventors:	Livneh; Noam (D.N. Misgav, IL) Ritz; Mordechai (Givat Elah, IL) Silbershatz; Giora (Haifa, IL)
Assignee:	Rafael Armament Development Authority (Haifa, IL)
Primary Examiner:	Olms; Douglas W.
Assistant Examiner:	Phillips; Matthew C.
Attorney Or Agent:	Diehl; Glen M.
U.S. Class:	370/330; 370/335; 370/433; 375/133
Field Of Search:	370/124; 370/118
International	

Class:

U.S Patent Documents: 4554668; 4860359; 4901307; 5239557; 5282222; 5408496

Foreign Patent Documents:

Other References:

Abstract: A multiple access communications system reuses a set of N carrier frequencies in adjacent comm to provide more than N minimally cross-correlated frequency-hopping communications channels. communications channels is associated with a first of the communications sites. No two of the ch first set employ the same frequency at the same time. A second set of communications channels with a second of the adjacent communications sites. No two of the channels in the second set of the same one of the N carrier frequencies at the same time. One or more sets of the minimally cr channels are further defined so that none of the channels in such sets employ the same frequenc time as more than a predetermined number of the channels in another of the sets of the minimal correlated frequency-hopping communications channels. The signal activity level of a frequency-h transmission is detected on one of the frequencies of the hopping pattern. The transmission is de the signal is silent. When signal activity resumes, the signal is transmitted with a new hopping se

Claim: Having described the invention, what is claimed as new and secured by Letters Patent is:

1. A method of providing multiple access communications in a communication system having a pl frequency channels in which signals are transmitted, comprising the steps of:

transmitting a signal spread over the plurality of fixed frequency channels in accordance with a s frequency channels;

detecting the signed activity level of the transmission of the signal on one of the plurality of fixed channels to generate a voice activity signal;

deactivating the transmission of the signal when the voice activity signal indicates that the signal

transmitting the signal in accordance with a new sequence of frequency channels when signal act

2. A multiple access communication system, comprising:

means for transmitting a signal spread over a plurality of fixed frequency channels in accordance of frequency channels;

means for detecting the signal activity level of the transmission of the signal on one of the plurali frequency channels to generate a voice activity signal;

means for deactivating the transmission of the signal when the voice activity signal indicates that silent; and

means for transmitting the signal in accordance with a new sequence of frequency channels wher resumes.

Description: BACKGROUND OF THE INVENTION

This invention relates generally to radiotelephone systems, and, more particularly, relates to met apparatus for implementing spread spectrum, frequency-hopping techniques in a radiotelephone system for use in specialmobile radio (SMR).

A plurality of communications channels may be defined in a given bandwidth of the radio frequen provide a radiotelephone system by assigning a plurality of distinct carrier frequencies in the ban

each channel. Suchsystems are called frequency-division multiple access (FDMA) systems. Altern communications channels may be defined by assigning discrete time slots for using a given carrie Such systems are called time division multiple access(TDMA) systems. In a still different system t may be defined by what is known as code division multiple access (CDMA).

One type of communications system that can be a CDMA system is a spread spectrum system. Sp communications systems can be implemented as multiple access systems in a number of differen One type of multiple accessspread spectrum system is a code division multiple access (CDMA) sy spread spectrum systems may use direct sequence (DS-CDMA) or frequency hopping (FH-CDMA) spreading techniques. FH-CDMA systems can be further divided into slowfrequency hopping (SFH frequency hopping (FFH-CDMA) system. In SFH-CDMA systems, several data symbols, representi data bits that are to be transmitted, modulate the carrier frequency within a single hop. In FFH-C contrast, the carrier frequency hops (changes) several times per data symbol.

FH-CDMA techniques have been proposed for cellular radiotelephone systems by Cooper and Nett was proposed in the context of cellular systems by Gilhousen et al.

There is increased channel capacity in a CDMA system over an FDMA system. The reason is that both types of systems are interference limited, the capacity of a FDMA system is determined by t interference that may exist inthe bandwidth, whereas the capacity of a CDMA system is determin average interference over the entire bandwidth. Such average interference is usually much small case interference, unless the interference is the same in allparts of the bandwidth. Additionally, C inherently incorporate frequency diversity, which mitigates multipath effects. Further, because of averaging ability of the CDMA system, the employment of Voice Activity Detection andDiscontinu (VAD) techniques increases the capacity by reducing the average interference level by the duty r speech. By utilizing appropriate parameters, both DS-CDMA and FH-CDMA can provide similar av capabilities.

A further advantage of FH-CDMA systems is that the bandwidth employed need not be contiguou

Frequency hopping and direct sequence techniques have been proposed and utilized in a number spectrum radio-telephone systems. Examples of such systems are set forth in the following:

____ 3,239,761 Goode 5,048,057 Saleh et al 4,066,96 4,176,316 DeRosa et al 4,554,668 Deman et al 4,979,170 Gilhousen et al 5,099,495 Mikoshiba e Gilhousen et al 5,051,998Murai et al 4,222,115 Cooper et al 4,704,734 Menich et al 4,933,954 Pe Scheller et al 5,065,449 Gordon et al 5,067,173 Gordon et al 4,144,411 Frenkiel 4,794,635 Hess Gilhousen et al EP 391,597 UK 2,242,806 ____

WO91/13502

WO91/15071

WO91/12681

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U.K. Patent Application 2,242,806

U.K. Patent Application 2,242,805

Cooper et al, "A SPREAD SPECTRUM TECHNIQUE FOR HIGH CAPACITY MOBILE COMMUNICATION

Viterbi, "NON-LINEAR ESTIMATION OF PSK-MODULATED CARRIER PHASE WITH APPLICATION TC TRANSMISSION". 1982, IEEE

Omura et al, "CODED ERROR PROBABILITY EVALUATION FOR ANTIJAM COMMUNICATION SYSTEI

Lempel et al, "FAMILIES OF SEQUENCES WITH OPTIMAL HAMMING CORRELATION PROPERTIES".

Verhulst et al, "SLOW FREQUENCY HOPPING MULTIPLE ACCESS FOR DIGITAL CELLULAR RADIO T 1984, IEEE

Mathematics which can be used for achieving orthogonality in a FH-CDMA system was suggested Greenberger in an article "Families of Sequences with Optimal Hamming Correlation Properties" p Transactions on Information Theory,Vol. IT 20, No. 1 January 1974.

U.S. Pat. No. 4,850,063 to Smith is directed to a dialing and synchronization sequence for a frequ radiotelephone communication system. This patent teaches a system in which all frequency hopp defined by using asequence of carrier frequencies within a bandwidth such that no one carrier fre by more than one channel at the same time. In this system, fewer frequency hopping channels ca a given bandwidth than would be provided if eachcarrier frequency defined a separate channel.

U.S. Pat. No. 4,554,668 to Deman et al. discloses a frequency hopping radio communications sys master station is used to communicate digitally with a plurality of slave stations. Each slave statio carrier frequencysequence, permanently assigned to it, to define its communications channel. Tim is extracted from the data stream.

UK patent application GB 242 805 A of Ramsdale et al. discloses that interference can be reduced sectorized into a group of smaller cells by means of a directional antenna; and also discloses that interferencereduction, adjacent microcells normally used different channels, as determined by a c allocation scheme. However, when movement of a handset is detected (such as by marginally BE strength or delay measurements), then a common"umbrella" channel is allocated to that handset microcells within a group of adjacent of nearby cells, that is a sub-array of the array.

U.S. Pat. No. 4,901,307 to Gilhousen indicates that in order to obtain a large number of users the error correcting coded communication signals using code division multiple access (CDMA) spread transmission, and disclosesthe use of different size cells. This patent also discloses beam steering directional antenna to reduce interference in a CDMA spread spectrum radio telephone system, a antenna.

Application WO 92/00639 discloses that information communicated on the cellular-to-mobile link encoded, interleaved, bi-phase (BPSK) modulated with orthogonal covering of each BPSK symbol quadrature phase shift key (QPSK)spreading of the covered symbols.

An article entitled Slow frequency Hopping Multiple Access for Digital Cellular Radiotelephone by ' published in IEEE Journal on Selected Areas in Communications, Vol. Sac-2, No. 4, July 1984, pa that one drawbackof frequency hopping multiple access is a reduction of spectrum efficiency, but control and silence detection are used, good capacity can be attained.

U.S. Pat. No. 4,144,411 to Frenkiel discloses the use of different cell sizes in a mobile communica

PCT application WO 91/15071 discloses the use of a multiplicity of cells referred to as clusters.

U.S. Pat. No. 4,704,734 discloses a Method and Apparatus for Signal Strength Measurement and Selection in Cellular Radio Telephone Systems.

PCT application WO 91/12681 discloses an Interconnecting and Processing System for Facilitating Hopping.

PCT application WO 91/13502 discloses a system utilizing Shared-Carrier Frequency-Hopping.

U.S. Pat. No. 5,056,109 discloses a power control system that acts in response to power in the cc signal received and signals that are generated at the remote station that are transmitted back.

U.S. Pat. No. 5,048,057 to Saleh et al. discloses a Wireless Local Area Network utilizing codes exl diversity, and the use of side information by the decoder to improve its ability to accurately recov presence ofinterference. This patent also mentions soft decision decoding.

PCT patent application number WO 92/00639 discloses a system with path diversity for a local ar telephone system.

Conventional spread-spectrum frequency hopping communications systems exemplified by the ab patents and publications, however, have a number of deficiencies. In particular, in some such sys to define channels with minimuminterference, the number of usable communications channels de the number of discrete, carrier frequencies used. This is characteristic, for example, of the systen Smith patent listed above.

It is an object of this invention to provide a frequency hopping spread spectrum radiotelephone s SMR systems.

It is accordingly an object of the invention to provide improved radiotelephone communication m

apparatus.

It is another object of the invention to provide a radiotelephone communication system wherein t discrete, usable communications channels exceeds the number of assigned carrier frequencies.

It is a further object of the invention to provide a radiotelephone communications system such th more evenly distributed among the communications channels to provide more quality communica

Other general and specific objects of the invention will in part be obvious and will in part appear l

SUMMARY OF THE INVENTION

The foregoing objects are attained by the invention, which in one aspect provides a multiple acce communications system in which a set of N carrier frequencies are reused in adjacent communica provide greater than N minimallycross correlated frequency hopping communications channels. T includes apparatus for defining a first set of minimally cross correlated frequency hopping commu channels associated with a first of the communications sites in which notwo of the channels in the minimally cross correlated frequency hopping communications channels employ the same one of frequencies at the same time and apparatus for defining a second set of the minimally cross corre hopping communications channels associated with a second of the adjacent communications sites of the channels in the second set of the minimally cross correlated frequency hopping communica employ the same one ofthe N carrier frequencies at the same time.

In a further aspect of this invention the system also includes apparatus for defining a third set of cross correlated frequency hopping communications channels associated with a third of the adjac communications sites in which notwo of the channels in the third set of the minimally cross corre hopping communications channels employ the same one of the N carrier frequencies at the same

In accordance with a still further aspect of this invention one or more sets of the minimally cross channels are further defined so that no one of the channels in such set or sets of the minimally cr frequency hoppingcommunications channels employ the same one of the N carrier frequencies at as more than a predetermined number of the channels in another of the sets of the minimally cro frequency hopping communications channels, where thepredetermined number is the minimum n channels possible. In the preferred embodiment the predetermined number is one.

Yet another aspect of this invention is that the second and third sets of the minimally cross corre hopping communications channels are decimated transformations of each of the minimally cross frequency hoppingcommunications channels in the first set.

Each of the minimally cross correlated frequency hopping communications channels in the first se unique sequence of the frequencies and the decimating transformation is performed on each of th cross correlatedfrequency hopping communications channels in the first set by selecting frequenc the minimally cross correlated frequency hopping communications channels in the first set in thei order skipping a first decimation number offrequencies in the sequence and repeating this proces remaining frequencies in the sequence of each channel in their remaining order until all of the fre channel are used to define a second set of minimally cross correlatedfrequency hopping commun and a second decimating transformation is performed on each of the minimally cross correlated fr hopping communications channels in the first set by selecting frequencies from each of the minim crosscorrelated frequency hopping communications channels in the first set in their sequential ord second decimation number of frequencies in the sequence and repeating this process on the rema frequencies in the sequence of each channel intheir remaining order until all of the frequencies in are used to define a third set of minimally cross correlated frequency hopping communications ch the first and second decimation numbers are different and each is less thanthe minimum factor o

In a yet further aspect of this invention the system also includes apparatus for selectively encodir information signals on certain of the minimally cross correlated frequency hopping communicatio that there is a redundantrelationship between channel bits. The error correcting code sets this rel the decoder utilizes it for error correction.

In the preferred embodiment of this invention soft decision making and side information are emp decoding. Voice activity detection is also employed to measure signal activity levels for selectively channels to subscribers. Apparatus is also provided for performing a conference call between a pl subscribers in a site by causing each of the subscribers to employ the same channel. Additional s be included in such conference call in other sites byusing the same approach and other conventio methods can be used to add parties using other telephone systems.

The invention further contemplates an electronically controlled antenna, apparatus responsive to for controlling the antenna to provide a first antenna radiation pattern for defining the first of the communicationssites, apparatus responsive to a control signal for controlling the antenna to prov antenna radiation pattern which overlaps with the first antenna radiation pattern at a boundary fo second of the adjacent communications sites;and apparatus responsive to the number of the syst using each of the first and second of the adjacent communications sites for affecting the control s the boundary.

The invention also contemplates apparatus for defining a first microsite within one or more of the communications sites, the first microsite also reusing the N frequencies. The micro-site has no gr the average power as theadjacent communications site it is in.

The present invention contemplates the option of direct communication between subscribers if th the micro-site by causing one of the two subscribers to communicate uplink with a first downlink downlink with an firstuplink channel, and causing the other of the two subscribers to communicat first uplink channel and downlink on the first downlink channel.

The invention will next be described in connection with certain illustrated embodiments; however clear to those skilled in the art that various modifications, additions and subtractions can be mad departing from the spiritor scope of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be made t detailed description and the accompanying drawings, in which:

FIG. 1 is a schematic diagram depicting a first plurality of communications sites operating in acco mobile communications system of the invention particularly suited for SMR systems;

FIG. 2 is a schematic diagram depicting operation of another embodiment of the invention, and s plurality of communications sites suited for cellular systems;

FIGS. 3A, 3B, 3C depict the construction of communications channels from sequences of frequen accordance with the invention;

FIG. 4 depicts a decimation transform in accordance with the invention;

FIG. 5 depicts the temporal relationship between frequency hops and transmission of digital infor accordance with the invention;

FIG. 6 is a block diagram depicting an encoding/decoding configuration in accordance with the in

FIG. 7 is a block diagram depicting the structure of a voice activity detection circuit in accordance invention;

FIG. 8 is a block diagram depicting duplex operation in accordance with the invention; and

FIG. 9 is a block diagram depicting an embodiment of the invention utilizing an electronic antenn control apparatus.

DESCRIPTION OF ILLUSTRATED EMBODIMENTS

System Overview

FIG. 1 is a schematic diagram depicting a first plurality of communications sites operating in acco mobile communications system of the invention.

Referring to FIG. 1, a geographic service coverage area scheme is shown. The geographic area of divided into a plurality of communications sites 102, 104, 106, 108 which are each served by a c communications station110 having a sectorized antenna 112. Of course as in most real systems t perfect geographic isolation between the various sectors. One sector of the sectorized antenna 11 of the sites 102, 104, 106, and 108.

A set of N carrier frequencies are reused in adjacent communications sites to provide greater tha cross correlated frequency hopping communications channels. This result is attained by defining a minimally crosscorrelated frequency hopping communications channels associated with the first o

communications sites 102 such that no two of the channels in the first set of the minimally cross frequency hopping communications channels employ the sameone of the N carrier frequencies at Apparatus and methods for defining the first set of communications channels is discussed in grea hereinafter in connection with FIGS. 3 and 4. As used herein, the term channel refers toeither a s channel or one which can be further subdivided into subchannels through known ways such as tir multiplexing.

A second set of the minimally cross correlated frequency hopping communications channels assoc second of the adjacent communications sites 104 is defined such that no two of the channels in tl the minimally crosscorrelated frequency hopping communications channels employ the same one frequencies at the same time. Apparatus and methods for defining the second set of communicat discussed in greater detail hereinafter.

Moreover, a third set of the minimally cross correlated frequency hopping communications chann with the third of the adjacent communications sites 106 is defined such that no two of the channe set of the minimallycross correlated frequency hopping communications channels employ the sam carrier frequencies at the same time. Apparatus and methods for defining the third set of commu channels is discussed in greater detail hereinafter.

In a preferred embodiment of the invention, at least one set of the minimally cross correlated cha so that no one of the channels in such set or sets of the minimally cross correlated frequency hop communications channelsemploy the same one of the N carrier frequencies at the same time as r predetermined number of the channels in another of the sets of the minimally cross correlated fre communications channels. This predetermined number ofchannels is the minimum number of cha In the preferred embodiment the predetermined number is one. This property is discussed in gre hereinafter in connection with FIGS. 3A, 3B, 3C, and 4.

Conventional CDMA systems can operate only under a multicell frequency reuse pattern, which is control interference. This may cause serious frequency management problems, particularly when to an existing cellularsystem. On the other hand, the CDMA system described herein can impleme frequency reuse pattern--i.e., the same frequencies can be reused in every communications site- the frequency planning problem that hampers currentcellular systems. Furthermore, a cell may b more than one communication site, as depicted in FIG. 1, which can be an important source for c For example, by dividing each omni-cell into four communications sites, asindicated in FIG. 1, ea same N carrier frequencies, significant additional channel capacity can be attained in the geograp as compared with a system that does not have the same frequency reuse pattern.

Cellular Configuration

FIG. 2 is a schematic diagram depicting operation of another embodiment of the invention having communications sites suited for cellular systems. In the illustrated cellular configuration, the geo coverage 200 isdivided into four communication cells 202, 204, 206, 208 which are each served l communications station and corresponding antenna 212, 214, 216, 218. As in the system discuss with FIG. 1, perfect geographic isolation doesnot exist between the various cells. In particular, ar exist between the communications cells 202, 204, 206, 208. In conventional cellular systems, int these areas of overlap has posed significant difficulty. In connectionwith the invention, however, the regions of overlap is minimized in the manner described above with regard to FIG. 1. More sp system provides sets of self orthogonal frequency hopping communications channels, wherein su characterized by minimal cross correlation between channels of different sets. When implemente configuration, as illustrated in FIG. 2, the FH-CDMA system described herein yields a one cell reu These aspects arediscussed in greater detail hereinafter.

Frequency Hopping Sequences

FIGS. 3A, 3B, 3C depict the construction of communications channels from sequences of carrier f accordance with the invention.

In particular, the minimally cross correlated frequency hopping communications channels describ defined in accordance with the code division technique illustrated in FIGS. 3A, 3B, and 3C.

FIG. 3A is a chart relating each channel 1, 2, 3, 4, to a unique series of frequency-hopping seque indicating the manner in which four orthogonal communications channels 1, 2, 3, 4 are defined fr frequencies 1, 2, 3, 4. . . , N. It should be noted that sequences 1, 2, 3, and 4 are identical to ea each shifted one time slot from each other, such that sequences 1, 2, 3, and 4 are mutually orth

As illustrated in FIGS. 3A, 3B, and 3C, multiple communication channels using the same carrier fr

attained by allocating the carrier frequencies to each communications channels at preselected tim
hopping sequencesare used to assign the carrier frequencies to different channels during the time
unique hopping sequences are selected so that they are orthogonal to one another in each site or
that the cross-correlation between the hoppingsequences for a given site or sector is zero.

Particular transmitted signals can be retrieved from the communications channel defined by such
sequence by using the hopping sequence in the receiver.

The hopping sequences are selected such that users in each site are assigned mutually orthogona
and inter-site correlation of frequency-hopping sequences is theoretically zero. In the preferred e
this invention there isonly one time that any carrier frequency when associated with a sequence c
particular channel in one site interferes with any particular channel in adjacent sites. Known Forw
Correction (FEC) and interleaving techniques can be employedin the system described herein to r
remaining interference. A system architecture providing these features is illustrated in FIG. 6.

With proper selection of system parameters, the frequency hopping code division multiple access
system described herein offers advantages previously asserted for direct sequence (DS-CDMA) sy
addition, the user capacity ofFH-CDMA is enhanced by the intrinsic interference averaging afforde
system, and can readily exploit the intermittent duty cycle associated with voice activity. Moreov
orthogonal operation described herein, interference fromco-users of a user's site is eliminated. Si
major source of interference in nonorthogonal systems typical of DS-CDMA systems, FH-CDMA yi
capacity and enhanced performance capabilities when structured as set forth above. Whenimplem
cellular configuration, as illustrated in FIG. 2, the FH-CDMA system described herein also yields a
reuse pattern.

From an implementation standpoint, the FH-CDMA system described herein can be readily implem
existing technologies. In particular, the mobile power control problem fundamental in DS-CDMA i
in FH-CDMA. The one cellfrequency reuse pattern alleviates the frequency management problem,
current cellular systems.

Yet another aspect of this invention is that the second and third sets of the minimally cross corre
hopping communications channels are decimated transformations of each of the minimally cross
frequency hoppingcommunications channels in the first set.

FIG. 4 depicts a decimation transform utilized in one practice of the invention. In accordance with
depicted in FIG. 4, each of the minimally cross correlated frequency hopping communications cha
set is defined bya unique sequence of the frequencies and the decimating transformation is perfo
the minimally cross correlated frequency hopping communications channels in the first set by sel
frequencies from each of the minimally cross correlatedfrequency hopping communications chann
set in their sequential order, skipping a first decimation number of frequencies in the sequence, a
this process on the remaining frequencies in the sequence of each channel in theirremaining orde
frequencies in each channel are used to define a second set of minimally cross correlated frequen
communications channels.

A second decimating transformation is performed on each of the minimally cross correlated frequ
communications channels in the first set by selecting frequencies from each of the minimally cros
frequency hoppingcommunications channels in the first set in their sequential order, skipping a se
number of frequencies in the sequence, and repeating this process on the remaining frequencies
of each channel in their remaining order,until all of the frequencies in each channel are used to d
of minimally cross correlated frequency hopping communications channels.

in accordance with the invention, the first and second decimation numbers are different and each
minimum factor of N, where the minimum factor of a number is the smallest number, greater tha
be divided into thenumber with a remainder of zero.

For example, suppose that Channel 1 of a first set of orthogonal frequency hopping communicatio
associated with a first communications site is defined by the following frequency hopping sequenc

wherein the numbers 1, 2, 3, 4 and 5 represent discrete carrier frequencies. Decimation is execu
of the first set by selecting frequencies from the above-listed frequency hopping sequence in seq
skipping a firstnumber of frequencies in the sequence. This number is referred to herein as the "d
number" or "decimation factor." For purposes of this example, suppose a decimation factor of 3.
above sequence with a decimation factor of 3yields the following frequency hopping sequence:

In accordance with the invention, this sequence is used to define Channel 1 of the second set of c
is associated with a second communications site.

Frequency hopping sequences for the remaining channels of Set 2 are constructed similarly, by d sequences for each of the channels of Set 1 by the same decimation factor of 3.

Then, to generate the frequency hopping sequence defining Channel 1 of the third set of channel: associated with the third communications site--the Set 1, Channel 1 sequence is decimated by a decimation number, selectingfrequencies from the Set 1, Channel 1 sequence in their sequential the second decimation number of frequencies in the sequence. In particular, the following sequer decimated, for example, by the decimation factor of 2, such thatthe decimation of the sequence

This process is repeated on the remaining frequencies in the sequence of each channel in their re until all for the frequencies in each channel are used to define a third set of minimally cross corre hoppingcommunications channels.

It will be appreciated that the above-described operations provide sets of sequences having minir correlation, and support communications sites or sectors in which no two of channels in a given s same one of the allocatedfrequencies at the same time. The resulting system is thus characterize operation within a given site or sector, and minimum sector-to-sector cross-correlation.

This system has the property that the number of available adjacent communications sites is one l minimum factor of the number of assigned frequencies. The minimum factor of a number is the s greater than one, that canbe divided into the number with a remainder of zero. Thus, if the numb frequencies is three, then the minimum factor is three, and the maximum number of adjacent mi correlated communications sites is two. If the number ofassigned frequencies is four, then the mi two, and only one site can be serviced.

Similarly, if the number of frequencies utilized is 10, then only one site can be serviced. If the nu frequencies utilized is seven, then six sites can be serviced. Accordingly, the maximum number o serviced by a system ofthis invention, using a given number of N of frequencies, if N is a prime n a preferred embodiment of this invention, the number N of frequencies is a prime number.

Interleaving and Forward Error Correction

The capacity of system described herein is determined by the average interference over the entir Such average interference is usually much smaller than the worst case interference, unless the in same in all parts ofthe bandwidth. In a multiple-site embodiment of the invention, interference ca form of collisions, i.e., simultaneous use of the same frequency at the same time, by users in the communications site, or by users in a differentcommunications site. System performance depend probability of collisions, and the power of the colliding interferer.

In order to reduce the effects of such collisions, a mobile communications system in accordance v invention encodes and interleaves digital information signals on the minimally cross correlated fre communications channelssuch that several information-representative digital channel symbols ar during each hop. As depicted in FIG. 5, in accordance with the slow frequency hopping scheme e invention, one hop occurs for every M channel symbols,where, for example, M=6.

Accordingly, as indicated in FIG. 5, corrupted bits from an interfered hop are separated by a num symbols S. This redundancy enables the utilization of known digital error correction techniques, s Error Correction(FEC), which detects errors due to collisions, rejecting selected ones of the redun INVALID, and accepting others as VALID. In accordance with the invention, at least two techniqu implemented to determine which ones of the redundantbits are to be accepted as VALID.

Under the first technique, a complex measure of each sampled value of the received signal is pro decision chart and is assigned a value (metric) that corresponds to the decision regions of such c the sampled value. The metric is fed to a conventional FEC decoder for soft error correction and c example of a configuration utilizing an FEC decoder is depicted in FIG. 6.

Under the second technique, a carrier/interference (C/I) ration is estimated for each hop. This es the FEC decoder to improve its performance. This technique can be implemented by detecting ea C/I ratio is below apredetermined threshold, and for each such hop, replacing the metric correspo hop with a null metric that does not affect the decision process of the FEC decoder.

Soft Decoding/Side Information

In the embodiment depicted in FIG. 6, system performance is further enhanced by implementing the known techniques of soft decision making and the use of side information.

Voice Activity Detection

In a preferred embodiment of the invention, system performance is also improved by employing Detection (VAD), which increases system capacity by reducing the average interference level by t the speech.

FIG. 7 is a block diagram depicting the structure of a voice activity detection circuit in accordance invention. The circuit 600 includes a voice activity detection module 602, a transmission control r a channel allocationcontrol module 606. The voice activity detection module 602 measures signal representative of subscriber voice activity on an assigned channel to generate a channel voice ac preferred embodiment of the invention includeselements responsive to the voice activity signal fo allocating channels to subscribers. A voice activity signal indicative of silence is used in a decisior program to deactivate the channel in question through the transmissioncontrol module 604. A se reallocates a channel to the subscriber upon resumption of voice activity through the channel allc 606.

Micro-Sites/Duplex Operation

A preferred embodiment of the invention provides apparatus for defining at least a first micro-site more of the adjacent communications sites, as depicted in FIG. 1. Each micro-site reuses the sam as are used by theadjacent communications sites. The micro-site is characterized, for example, b power of less than or equal to 10% the average power as the adjacent communications site in wh situated. This power ratio is provided by way of exampleonly, and other micro-site power levels n in connection with the invention. A micro-site is utilized for high usage areas, or areas in electron shadows, or to extend a communications sector or site.

Under current governmental regulations, two sets of frequencies are assigned by the FCC for SMI set is utilized for uplink transmission from mobiles to the base station, while the other is dedicate transmission fromthe base station to mobile units. A fixed gap, for example, 39 MHz or 45 MHz is between these two sets, and channels are assigned in pairs, one for downlink and one for uplink.

The present invention utilizes appropriate allocation of downlink and uplink channels to provide th direct communication between subscribers who are in the same micro-site. Such communication duplex operation.

FIG. 8 is a block diagram depicting duplex operation in accordance with the invention. As illustrat subscribers can be directly linked by allocation of uplink and downlink channels. In particular, dup isimplemented by causing one of the two subscribers to communicate uplink with a first downlink downlink with a first uplink channel, and causing the other of the two subscribers to communicate first uplink channel and downlink onthe first downlink channel.

Thus, in accordance with the invention, the capability of full duplex operation is provided so that can communicate directly to each other without going through the base station, by having one su assigned the same uplinkchannel as the other subscriber with whom direct communication is to b for its downlink channel and vice versa. Similarly, the configuration depicted in FIG. 8 provides th performing a conference call between multiplesubscribers within a given communications site by said subscribers to employ the same channel.

Flexible Sector/Site Boundaries

As indicated by dashed lines in FIG. 1, the boundaries of the communications sites are flexible. Ir preferred embodiment of the invention, depicted in FIG. 9, employs an electronically controlled a apparatus responsive to acontrol signal for controlling the antenna to provide a first antenna radi defining the first of the adjacent communications sites, apparatus responsive to a control signal f antenna to provide a second antennaradiation pattern which overlaps with the first antenna radia boundary for defining the second of the adjacent communications sites; and apparatus responsiv of system subscribers using each of the first and second ofadjacent communications sites for cau signal to move the boundary.

Multiple antennas

Referring again to FIG, 2, the cellular system depicted therein utilizes four antennas having respe radiation patterns for defining first, second, third and fourth adjacent communications sites. A fift utilized in thesystem has a respective fifth antenna radiation pattern for defining a micro-site witl communications site. The micro-site reuses the same N frequencies utilized by the plurality of adj

communications sites, while the radiation patternof the fifth antenna defining the micro-site may characterized, for example, by a mean power of no more than ten percent that of the other anter patters. The ten percent power level is provided by way of example only, and other powerlevels r to define a micro-site.

It will thus be seen that the invention efficiently attains the objects set forth above, among those from the preceding description. In particular, the invention provides a mobile communications sy: the number of usablecommunications channels exceeds the number of allocated carrier frequenci CDMA system described herein provides a capacity that is superior to all known cellular systems.

It will be understood that changes may be made in the above construction and in the foregoing s operation without departing from the scope of the invention. It is accordingly intended that all mε in the above descriptionor shown in the accompanying drawings be interpreted as illustrative ratl limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and s of the invention as described herein, and all statements of the scope of the invention which, as a language, might besaid to fall therebetween.

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In addition to the higher utilization of the spectrum, the interleaved nature of .... H. Fathallah and L. Rusch, "Robust optical FFH-CDMA communications: ...
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groups, and assigned the codes, which interleaved to each other. to the different groups. ... first FFH-CDMA in optical domain is proposed by using an ...
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ENHANCED OPTICAL FAST FREQUENCY HOPPING-CDMA BY MEANS OF OVER SPREADING AND INTERLEAVING FIELD OF THE INVENTION The present invention relates generally to ...
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(WO/1993/006663) DATA PACKET ALIGNMENT IN A COMMUNICATION SYSTEM
One method is to add the information to the spreading code before it is used ... in FFH-CDMA systems, the carrier wave hops several times per data symbol. ...
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H. Fathallah et al., Enhanced optical fast frequency hopping-CDMA by means of over spreading and interleaving, WO2004030254 (APN) ...
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Code Acquisition in Direct Sequence Spread Spectrum Communication Systems Using an Approximate Fast Fourier Transform Coding for FFH-CDMA Systems - Part I: ...
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Improved Fiber Bragg Grating Array OFFH-CDMA System Using a Novel Frequency-Overlapping Multigroup Method

Wei-Ren Peng, Wen-Piao Lin, and Sien Chi

Journal of Lightwave Technology, Vol. 24, Issue 3, pp. 1072-

Abstract
The authors propose a novel frequency-overlapping multigroup scheme for a passive all-optical fast-frequency hopped code-division multiple-access (OFFH-CDMA) system based on fiber Bragg grating array (FBGA). In the conventional scheme, the users are assigned those codes constructed on the nonoverlapping frequency slots, and therefore the bandgaps between the adjacent gratings are wasted. To make a more efficient use of the optical spectrum, the proposed scheme divided the users into several groups, and assigned the codes, which interleaved to each other to the different groups. In addition to the higher utilization of the spectrum, the interleaved nature of the frequency allocations of different groups will make the groups less correlated and, hence, lower the multiple-access interference (MAI). The corresponding codeset and its constraints for this new scheme are also developed and analyzed. The performance of the system in terms of the correlation functions and bit error rate (BER) are given in both the conventional and the proposed schemes. The numerical results show that, with the multigroup scheme, performance is much improved compared to the conventional scheme.

Citation
W. Peng, W. Lin, and S. Chi, "Improved Fiber Bragg Grating Array OFFH-CDMA System Using a Novel Frequency-Overlapping Multigroup Method," J. Lightwave Technol. 24, 1072- (2006)
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1. Coherent frequency hopping multiple access (CFHMA) with multiuser de communication systems
Tomisato, S.; Fukawa, K.; Suzuki, H.;
Vehicular Technology, IEEE Transactions on
Volume 49, Issue 2, March 2000 Page(s):531 - 539
Digital Object Identifier 10.1109/25.832984
AbstractPlus | References | Full Text: PDF(240 KB) IEEE JNL
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IEEE CNF	IEEE Conference Proceeding
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1. Secure interleaving - physical layer built-in security enhancement of CD
Qi Ling; Tongtong Li; Jian Ren; Anil Jain;
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5. CDMA overlay situations for microcellular mobile communications
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10529229, filed 09/19/2005
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Application Number: 10/529229 Assignments	Examiner Number: 80488 / TORRES, JUAN
Filing or 371(c) Date: 09/19/2005 eDan	Group Art Unit: 2611 IFW Madras
Effective Date: 03/25/2005	Class/Subclass: 375/132.000
Application Received: 03/25/2005	Lost Case: NO
Pat. Num./Pub. Num: /20060120434	Interference Number:
Issue Date: 00/00/0000	Unmatched Petition: NO
Date of Abandonment: 00/00/0000	L&R Code: Secrecy Code:1
Attorney Docket Number: 87367.2700	Third Level Review: NO Secrecy Order: NO
Status: 30 /DOCKETED NEW CASE - READY FOR EXAMINATION	Status Date: 10/18/2007
Confirmation Number: 2140	Oral Hearing: NO

Title of Invention: ENHANCED OPTICAL FAST FREQUENCY HOPPING-CDMA BY MEANS OF OVER SPREADING AND INTERLEAVING

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Inventor Name	City	State/Country
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FOULI, KERIM	SAINTE-FOY	CANADA

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Inventor Name Search Result

Your Search was:

Last Name = FATHALLAH
First Name = HABIB

Application#	Patent#	Status	Date Filed	Title	Inventor Name
09192180	6381053	150	10/08/1998	FAST FREQUENCY HOPPING SPREAD SPECTRUM FOR CODE DIVISION MULTIPLE ACCESS COMMUNICATION NETWORKS (FFH-CDMA)	FATHALLAH, HABIB
10116042	Not Issued	161	04/05/2002	Fast frequency hopping spread spectrum for code division multiple access communications networks (FFH-CDMA)	FATHALLAH, HABIB
10452137	6915037	150	06/03/2003	LOSSLESS OPTICAL DIVIDER/COMBINER WITH PUMP DIVERSION FOR SCALABLE OPTICAL NETWORKS	FATHALLAH, HABIB
10475111	Not Issued	161	04/23/2004	Optical sources and transmitters for optical telecommunications	FATHALLAH, HABIB
10476244	Not Issued	164	05/14/2004	METHOD FOR THE OCDMA ENCODING OF OPTICAL SIGNALS	FATHALLAH, HABIB
10476446	Not Issued	161	06/08/2004	Optical communications system and method for transmittin point-to-point and broadcast signals	FATHALLAH, HABIB
10529229	Not Issued	30	09/19/2005	Enhanced optical fast frequency hopping-cdma by means of over spreading and interleaving	FATHALLAH, HABIB
60264007	Not Issued	159	01/26/2001	High bandwith optical fast frequency hopping for code division multiple access communications	FATHALLAH, HABIB
60264011	Not Issued	159	01/26/2001	Lossless optical divider/combiner with pump diversion	FATHALLAH, HABIB
60284194	Not Issued	159	04/18/2001	Waveband incoherent optical fiber sources and transmitters	FATHALLAH, HABIB

60287371	Not Issued	159	05/01/2001	OCDM-based simultaneous broadcast and point-to-point distribution	FATHALLAH, HABIB
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60384416	Not Issued	159	06/03/2002	Lossless optical divider/combiner with pump diversion	FATHALLAH, HABIB
60413134	Not Issued	159	09/25/2002	Enhanced optical fast frequency hopping-CDMA by means of over spreading and interleaving	FATHALLAH, HABIB
60579654	Not Issued	159	06/16/2004	OFFH-CDM all-optical network	FATHALLAH, HABIB
60907236	Not Issued	159	03/26/2007	Optical coding-OTDR technology to characterize multi-path optical waveguides and manage FTTH, PONs, and WDM optical networks	FATHALLAH, HABIB

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Last Name = FOULI
First Name = KERIM

Application#	Patent#	Status	Date Filed	Title	Inventor Name
10529229	Not Issued	30	09/19/2005	Enhanced optical fast frequency hopping-cdma by means of over spreading and interleaving	FOULI, KERIM
60579654	Not Issued	159	06/16/2004	OFFH-CDM all-optical network	FOULI, KERIM

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